Offshoring under Uncertainty

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Abstract

We develop a novel theoretical framework of offshoring under uncertainty. This model highlights the rigidity of a foreign country's labor markets as a key factor shaping a firm's ability to react upon demand or supply shocks. Applying this model to the case of the U.S., we derive the following two key testable predictions: The propensity of U.S. firms to source intermediate inputs from foreign rather than domestic suppliers decreases in a foreign country's labor market rigidity, and this effect is particularly pronounced in industries with higher volatility. Combining industry-level data on the U.S. offshoring intensity with measures of labor market rigidity and industry volatility, we find empirical evidence strongly supportive of the model's predictions.

Keywords: Offshoring, uncertainty, labor market rigidity, industry volatility

JEL-Classifications: F14, F16, F23

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1 Introduction

Over the past four decades, advances in the technology of transportation and communication have facilitated an unprecedented international fragmentation of production, see Johnson and Noguera (2012, 2017). Production processes are spread across many different countries in a manner that reflects a trade-off between a foreign cost advantage for certain slices of the value added chain and the additional cost arising from 'slicing-up' the value chain. There is a large economic literature analyzing this trade-off using models inspired by established trade theory, see, e.g, Jones (2000), Grossman and Rossi-Hansberg (2008), Feenstra (2010), and Baldwin and Robert-Nicoud (2014). Albeit these models have significantly contributed to our understanding of the phenomenon of offshoring, they are typically built upon a simplifying assumption of deterministic outcomes.[1] Recent empirical studies pose a major challenge to this assumption by showing that firms in a globalized world are increasingly exposed to uncertainty, see, e.g., Bloom (2009) and Baker et al. (2016). The aim of this paper is to enhance our understanding of firms' offshoring decisions under uncertainty, both from a theoretical and an empirical perspective.

We develop a novel theoretical model in which final good producers decide whether to source intermediate inputs from domestic or foreign suppliers against the backdrop of future demand or supply shocks. In each destination, firms choose whether to deal with their suppliers under flexible or rigid contractual arrangements. A flexible contract allows final good producers to select a state-contingent quantity of intermediate inputs upon the realization of the shock, but is associated with additional labor adjustment costs. These costs capture the expenses needed for hiring additional employees in case of a 'good' shock or severance payments to laid off workers in a 'bad' state, and are determined by the rigidity of a country's labor market. By stipulating a fixed quantity of intermediate inputs in a rigid contract, parties avoid these labor adjustment costs but can no longer react upon future shocks. We show that final good producers under uncertainty are ceteris paribus more likely to engage in flexible rather than rigid contracting the higher an industry's volatility, defined as the deviation between the good and the bad shocks.

Assuming firm heterogeneity with respect to productivities, final good producers self-select into different sourcing destinations (domestic vs. foreign) and contractual arrangements (rigid vs. flexible). Under plausible conditions, we obtain the following sorting pattern: The least productive firms source their inputs domestically, while high-productive firms engage in offshoring. Intuitively, only most productive firms are able to cover the costs associated

[1] We review a few exception that study offshoring under uncertainty further below.

with international fragmentation of production and offshore their input supply to exploit the foreign cost advantage. Among those firms that engage in offshoring, the least productive ones source their inputs under a rigid contract, while only the most productive ones engage in flexible contracting. Intuitively, only the most productive firms find it profitable to incur additional labor adjustment costs to be able to effectively react upon future shocks under a rigid contract. Hence, the productivity-based sorting pattern in our model crucially depends on the rigidity of a foreign country's labor market.

We apply our model to study the effect of the variation in a foreign country's labor market rigidity on the U.S. offshoring intensity, defined as the propensity of U.S. firms in a given industry to source inputs from foreign rather than domestic suppliers.[2] The model delivers the following two key testable predictions: First, an increase in the rigidity of a foreign country's labor market ceteris paribus decreases the share of U.S. inputs imported from that country in the total (i.e., domestic and foreign) input purchases. Intuitively, as foreign labor market rigidity increases, some firms that would have previously sourced inputs under flexible agreements switch to rigid contracts. Since, in the presence of uncertainty, the latter are associated with lower expected operating profits, firms decide to source a smaller amount of manufacturing inputs from the foreign destination and the offshoring intensity decreases. Second, the negative effect of foreign labor market rigidity on the U.S. offshoring intensity is stronger the higher an industry's volatility. The intuition behind this prediction builds on the previously mentioned finding that the relative advantage of flexible contracts weighs more heavily in volatile industries. Hence, if foreign labor market rigidity increases and some firms switch to a rigid contract, operating profits of those firms decrease more strongly in volatile industries and firms' reaction in terms of a reduced amount of imported inputs is more pronounced. To sum up, our model predicts a negative direct effect of a foreign country's labor market rigidity and a negative interaction between foreign labor market rigidity and industry volatility in their impact on the U.S. offshoring intensity.

In the empirical part of the paper, we bring these two theoretical predictions to the data. The measure of U.S. offshoring intensity is drawn from Antràs (2015) who calculates it as the share of spending on imported inputs over total input purchases in a particular industry. This measure is available on a yearly basis for 253 manufacturing sectors (according to IO2002 industry classification) and 232 foreign countries for the period 2000-2011. We further draw from Antràs (2015) an industry-level proxy for volatility, computed following the methodology by Cuñat and Melitz (2012) as the standard deviation of the annual growth

[2] We choose the United States as a "home" country since our subsequent empirical analysis is U.S.-centered. However, our theoretical predictions generally apply to any country with high production costs and flexible labor markets.

rate of firm sales in the 1980-2004 Compustat data. We complement these data with a well-established country-level measure of labor market rigidity drawn from the World Bank's Doing Business database.[3] This measure captures the difficulty of hiring or firing a new worker, and restrictions on expanding or contracting the number of working hours, combined into a single score based on the methodology developed by Botero et al. (2004). It is available on a yearly basis for 180 countries during the period 2004-2009. Importantly, this score exhibits sufficient variation over time which allows us to study changes in foreign labor market rigidity while controlling for time-invariant country-level factors via country fixed effects.

Our empirical analysis proceeds in two steps. In the first step, we explore the effect of the variation in labor market rigidity and the U.S. offshoring intensity. Controlling for country, industry, and year fixed effects, as well as a range of time-varying country-level factors, we find a negative and significant association between a higher foreign country's labor market rigidity in a given year and the U.S. offshoring intensity. This finding is consistent with our first theoretical prediction which suggests that the propensity of U.S. firms to source inputs from foreign rather than domestic producers decreases as a foreign country's labor market rigidity increases.

In the second step, we explore the interaction effect between labor market rigidity and industry volatility on the U.S. offshoring intensity. The fact that the explanatory variable in this case varies by country/industry/year allows us to even more effectively control for observable and unobservable factors using (various combinations of) fixed effects (such as country/year and industry, or country/industry and year). Throughout specifications, we find a negative and highly significant interaction effect of labor market rigidity and industry volatility on the U.S. offshoring intensity. This effect is robust to controlling for a range of country/industry/year-specific factors and correcting for a potential sample selection bias. Following Levchenko (2007), we further account for a differential impact of a foreign country's economic development across U.S. industries by adding a full set of interaction terms of a foreign country's GDP per capita with industry dummies. Our empirical findings yield strong support for the second theoretical prediction: The negative effect of foreign labor market rigidity is more pronounced in industries with high volatility.

This paper relates to several strands of research. Our theoretical model builds on the offshoring framework developed by Antràs (2015), which features productivity-based self-selection of firms into domestic versus foreign sourcing. We extend this framework with the notion of (demand and supply) uncertainty and highlight the trade-off between rigid

[3] Since the seminal contribution by Cuñat and Melitz (2012), this measure has been frequently used in the literature as a proxy for labor market rigidity vs. flexibility, see Nunn and Trefler (2014).

and flexible contracting in dealing with this uncertainty. Deriving novel testable predictions regarding the effect of foreign labor market rigidity and its interaction with industry volatility on the U.S. offshoring intensity, we relate to the theoretical model by Cuñat and Melitz (2012) who study the interaction effect between labor market flexibility and industry volatility on a country's comparative advantage. Extending a Ricardian model of trade with the notion of uncertainty, the authors show that countries with more flexible labor markets specialize in sectors with higher volatility and export final goods from those sectors. We complement their findings by showing how the interaction between labor market rigidity and industry volatility affect the attractiveness of a country as an offshoring destination for intermediate input production.[4]

To the best of our knowledge, the only two theoretical contributions which consider offshoring under uncertainty are Bergin et al. (2011) and Benz et al. (2016). Both papers focus on the effect of offshoring on employment volatility. More specifically, Bergin et al. (2011) set-up a stochastic model to explain the so-called 'offshoring volatility puzzle': maquiladora industries in Mexico exhibit larger employment volatility than the corresponding industries in the U.S., although Mexico has a more rigid labor market compared to the U.S., see Bergin et al. (2009). In their model, offshoring acts as transmission channel through which domestic booms or recessions are amplified in a foreign destination. Benz et al. (2016) develop a framework of intertemporal optimization to study how offshoring affects hiring and firing decisions of firms and, therefore, employment volatility in the sourcing and the source country. The current paper differs from these contributions both in terms of focus and the underlying approach. Our aim is to better understand the role of labor market institutions on firms' offshoring decisions under uncertainty. In our framework, offshoring *per se* does not affect a firm's (employment) volatility. It is the combination of a foreign country's labor market rigidity and sector-specific exposure to shocks, which drives firms' offshoring decisions and affects the variation in firm-level outcomes.

We further relate to the empirical literature which studies the role of (labor market) institutions in international transactions. In particular, Cuñat and Melitz (2012) provide empirical support for their key theoretical prediction: The exports of countries with more flexible labor markets are biased towards high-volatility sectors. This empirical regularity has been subsequently corroborated using different data by Chor (2010) and Nunn and Trefler (2014). Considering various institutional proxies, Antràs (2015) finds, among other things, a positive *interaction effect* between labor market flexibility (an inverse of labor market

[4] The role of uncertainty in international trade has been also analyzed by Albornoz et al. (2012), Carballo (2015), Handley and Limão (2015, 2017), Nguyen (2012), Segura-Cayuela and Vilarrubia (2008). In contrast to these contributions, we focus on offshoring relationships.

rigidity) from the year 2004 and industry volatility on the U.S. offshoring intensity. Yet, this empirical regularity cannot be interpreted in and of itself without knowing whether the *direct effect* of labor market flexibility is positive or negative. To this end, we first investigate the direct relationship between labor market rigidity and U.S. offshoring intensity and, in the second step, consider its interaction with industry volatility. In contrast to Antràs (2015), who considers the role of labor market institutions in a pooled OLS setting, we exploit the time variation of the index of labor market rigidity, which allows us to control for unobservable country-specific characteristics using country fixed effects.

The remainder of the paper is structured as follows. Section 2 lays out the theoretical model of demand and supply uncertainty, discusses the equilibrium of the game, and derives testable predictions. Section 3 brings these predictions to the data. Section 4 concludes.

2 Theoretical model

This section we develop a novel theoretical model of offshoring under uncertainty. In our framework, firms may face uncertainty regarding the demand for their final goods or supply (cost) of intermediate inputs. To develop our argument in a simplest possible manner, we examine the two uncertainty types one at a time, starting with demand uncertainty in section 2.1, followed by supply uncertainty in section 2.2.

2.1 Demand uncertainty

2.1.1 Baseline set-up

Our point of departure is the canonical framework of offshoring presented in Chapter 2 of Antràs (2015). The domestic economy hosts several symmetric industries, in each of which firms produce differentiated varieties of final goods under monopolistic competition. For ease of notation, we abstain from indexing industries and focus on a single sector . Production of final goods necessitates two parties: a headquarter firm (H) and a manufacturing supplier (M).[5] H provides headquarter services (h), while M produce manufacturing components (m). The headquarter firm combines both inputs into final goods according to the Cobb-Douglas production function:

$$x = \theta \left(\frac{h}{\eta}\right)^{\eta} \left(\frac{m}{1-\eta}\right)^{1-\eta}, \tag{1}$$

[5] The manufacturing supplier may be either integrated into a headquarter firm's boundaries or act as an independent subcontractor. Since organization of firms does not lie in the focus of our analysis, we abstract from modeling the make-or-buy decision.

whereby $\theta \in (0, \infty)$ represents a headquarter's productivity and $\eta \in (0,1)$ is an industry-specific parameter which captures the relative importance of headquarter services in the production process, henceforth called the headquarter intensity. Each of the two inputs is produced using labor – the only factor of production.

Headquarter firms are located strictly in the domestic economy, while manufacturing inputs can be provided either by domestic or foreign suppliers. In the former case we speak of domestic (d) sourcing, while the latter case is referred to as offshoring (o). Since our subsequent empirical analysis is U.S.-centered, we refer to the domestic economy as the U.S.[6] In our baseline model, we consider a single foreign economy.[7] For simplicity, we normalize the unit labor input requirement for domestic production of h to unity and let ℓ denote the amount of labor needed to produce one unit of m, assumed to be the same in the domestic and foreign country. We normalize the domestic wage rate to unity and use w to denote the foreign wage rate relevant for offshore production of m. Throughout the analysis, we assume a foreign wage advantage, $w < 1$. However, in case H decides to source manufacturing inputs from a foreign supplier, this involves iceberg-type trade costs, $\tau > 1$. Moreover, offshore provision of the input m entails additional fixed costs, incurred by H in terms of domestic labor. Hence, denoting the fixed cost of production by F_z, $z \in \{d, o\}$, we have $F_d < F_o$.

Assuming constant elasticity of substitution (CES) preferences, the revenue from selling a quantity x of a representative variety of the final good may be written as:

$$R = x^{\frac{\sigma-1}{\sigma}} A^{\frac{1}{\sigma}}, \tag{2}$$

where $\sigma > 1$ denotes the elasticity of substitution between any two differentiated varieties and $A := \beta E P^{\sigma-1}$ is a demand shifter, whereby $\beta \leq 1$ represents the fraction of consumers' total expenditures E falling on differentiated varieties of the considered sector and P is this sector's CES price index (taken as given by profit maximizing firms), see Antràs (2015).

We depart from Antràs (2015) and the vast majority of the offshoring literature by assuming that headquarters face uncertainty. In our baseline model, headquarters are uncertain about the state of demand for their final goods.[8] We model this uncertainty by assuming that the demand shifter A can be hit by a good (G) or a bad (B) shock. Thus, $A = A_s$, whereby $s \in \{G, B\}$ and $A_G > A_B$. A good state of demand may be caused by an increase in consumers' total expenditures E, a preference shift towards goods from a given sector

6 Nevertheless, our predictions generally apply to any home country with high production costs and flexible labor markets (see below).

7 As discussed below, our framework can be easily extended to a multi-country model.

8 The alternative case of supply (cost) uncertainty is developed in section 2.2.

β, or an increase in a sector's price index P (implying lower competition from rival firms). The probability of a good state $g \in (0,1)$ is assumed to be known by firms.[9] For simplicity, we assume the same g, A_G, and A_B for all firms within a given sector, but allow for cross-sectoral differences in volatility, defined further below. Courts can verify the state of the world, $s \in \{G, B\}$.

Unlike Antràs (2015), we assume that courts can verify and enforce contracts between H and M. In view of future uncertainty, headquarters decide between two contractual types: a rigid (r) and a flexible (f) contract. In a rigid contract, parties stipulate ex-ante (i.e., before the state of the world is realized) a fixed quantity of the manufacturing component, m_z^r, to be delivered by M regardless of the state of demand. A flexible contract is a state-contingent agreement, which allows H to stipulate the quantity of manufacturing inputs m_{zs}^f after the state of demand $s \in \{G, B\}$ is revealed. As will become clear below, the headquarter optimally chooses a high (low) amount of the headquarter input in the good (respectively, bad) state of the world. These amounts will also differ between the cases of flexible and rigid contracting. To be able to promptly react upon the headquarter's request after the realization of the shock, the supplier has to incur a fixed labor $a$djustment cost F_{az}.[10] One may think of this cost as expenses needed for hiring additional employees in a good state of the demand, severance payments to laid off workers in a bad state of the world, premium paid to current employees for night/overtime work, etc. Plausibly, the more flexible the labor market in the supplier's country, the lower this fixed cost. Given that U.S. turns out to have one of the most flexible labor markets in the world (see below), we assume $F_{ad} < F_{ao}$. For simplicity, we normalize $F_{ad} = 0$ which implies $F_{ao} > 0$.

In both countries, there is a large pool of potential suppliers with zero outside options. To secure participation of a supplier in a rigid contract, M must be compensated by a per-unit payment p_z, which is equal to a supplier's variable production cost:

$$p_z = \begin{cases} \ell & \text{if } z = d \\ \tau w \ell & \text{if } z = o \end{cases} \tag{3}$$

We assume throughout that the effective unit cost of manufacturing inputs are lower under offshoring, $\tau w < 1$. In addition, to ensure a supplier's participation under a flexible agreement, H has to compensate the supplier's for the labor adjustment cost F_{az}.

There are two stages of decision making, separated by the shock to the state of demand.

[9] According to Knight (1921), the notion of risk differs from uncertainty in that the probability of a shock can be quantified in the former case. Throughout the paper, we use the two concepts interchangeably.

[10] The assumption of a fixed nature of these costs greatly simplifies our analysis. This approach can be rationalized by a richer model of labor adjustment costs along the lines of Bagliano and Bertola (2004).

We refer to t_1 as the (ex-ante) period in which decisions prior to the shock have to be made, while t_3 refers to the period after the realization of the shock (ex-post). The sequencing of decisions is as follows:

- t_1 The headquarter decides about the location of sourcing, z, and incurs the fixed cost F_z. In addition, H decides whether to use a rigid or a flexible contract. Under a rigid contract, parties stipulate a fix amount of the manufacturing component, m^r_z. Under a flexible agreement, parties stipulate an amount of m^f_{zs} contingent upon the realization of the state $s \in \{G, B\}$. Under either type of contract, H commits to compensate M by paying the price p_z per unit of m. A flexible contract additionally involves H's commitment to pay a fixed fee F_{az}, compensating the supplier for the cost of ex-post adjustment to the state-contingent quantity m^f_{zs}.

- t_2 The shock $s \in \{G, B\}$ occurs.

- t_3 Ex-ante contracts between H and M are fulfilled. In addition, H chooses a profit-maximizing quantity of input h, given the state of nature and the contracted quantity of the input m. Specifically, having chosen a rigid contract in t_1, H will determine a quantity h^r_{zs}, depending on m^r_z and the state of nature s. Analogously, H chooses h^f_{zs} in case of a flexible contract.[11] Finally, given optimal input quantities, production of the final good takes place in line with equation (1) and revenue is generated according to equation (2).

In what follows, we solve this game using backward induction.

2.1.2 Equilibrium

Domestic sourcing. We begin our analysis by studying domestic sourcing, $z = d$. Consider first the case of a *flexible* contract. A flexible agreement effectively allows H to simulaneously choose the levels of both inputs conditional on the state of demand $s \in \{G, B\}$. The corresponding maximization problem reads as

$$\max_{h,m} R_s - \ell m - h - F_d, \tag{4}$$

whereby R_s is given by equations (2) and (1), and ℓ denotes the per-unit price of domestically sourced manufacturing inputs, as specified in equation (3). The solution to this problem

[11] Even though H chooses a state-specific amount of h under either contractual form, these amounts depend on whether M operates under a rigid or a flexible contract. For this reason, we distinguish h with a superscript r vs. f.

determines the state-contingent quantity m^f_{ds} stipulated in the flexible contract in t_1 as well as the corresponding h^f_{ds} chosen by H in t_3. Using equations (1) and (2), these quantities and the associated state-dependent revenue emerge as follows:

$$h^f_{ds} = \frac{\eta(\sigma-1)R^f_{ds}}{\sigma} \quad , \quad m^f_{ds} = \frac{(1-\eta)(\sigma-1)R^f_{ds}}{\ell\sigma} \quad , \quad R^f_{ds} = \sigma\ell^{-\gamma}\Theta\Gamma A_s. \tag{5}$$

In these expressions $\Theta := \theta^{\sigma-1}$ captures the firm's productivity level, while the terms $\Gamma := \frac{(\sigma-1)^{\sigma-1}}{\sigma^\sigma} > 0$ and $\gamma := (1-\eta)(\sigma-1) > 0$ are introduced for notational simplicity. Since $A_G > A_B$, the optimal amounts of both inputs are higher in the good state of demand than in the bad state. Plugging (5) into (4), we obtain the state-specific profit from domestic sourcing under a flexible contract:

$$\pi^f_{ds} = \ell^{-\gamma}\Theta\Gamma A_s - F_d. \tag{6}$$

Hence, the expected profit from domestic sourcing under a flexible contract is given by

$$E(\pi^f_d) = \ell^{-\gamma}\Theta\Gamma(gA_G + (1-g)A_B) - F_d. \tag{7}$$

Next, consider a *rigid* contract. In t_3, H chooses the amount of h that maximizes

$$\max_h R_s - h - F_d, \tag{8}$$

conditional on the quantity m^r_d chosen in period t_1. Using equations (1) and (2), the optimal quantity of h chosen in t_3 and the associated revenue read as

$$h^r_{ds} = \frac{\eta(\sigma-1)R^r_{ds}}{\sigma} \quad , \quad R^r_{ds} = \left(\theta\left(\frac{\sigma-1}{\sigma}\right)^\eta \left(\frac{m^r_d}{1-\eta}\right)^{1-\eta}\right)^{\frac{\sigma-1}{\sigma(1-\eta)+\eta}} A_s^{\frac{1}{\sigma(1-\eta)+\eta}}. \tag{9}$$

In state s, H receives the following revenue net (n) of the cost of headquarter services (henceforth, net revenue):

$$R^r_{dsn} := R^r_{ds} - h^r_{ds} = \frac{\sigma(1-\eta)+\eta}{\sigma} R^r_{ds}. \tag{10}$$

Expected net revenue from a rigid contract may be written as

$$E(R^r_{dsn}) = \frac{\sigma(1-\eta)+\eta}{\sigma}(gR^r_{dG} + (1-g)R^r_{dB}), \tag{11}$$

whereby R^r_{ds} is given by the second expression in equation (9).

In t_1, the headquarter stipulates the fixed amount of m so as to maximize the expected net revenue:

$$\max_{m} E(R^r_{dsn}) - \ell m - F_d, \tag{12}$$

where we have again used equation (3) above. Using equations (9) and (11), this optimization problem can be solved to obtain the profit-maximizing fixed quantity of m under a rigid contract:

$$m^r_d = \frac{(1-\eta)(\sigma-1)E(R^r_{dsn})}{\ell(\sigma(1-\eta)+\eta)}. \tag{13}$$

Inserting for m^r_d in the expression for R^r_{ds} in equation (9), and substituting this expression back in (11), we get

$$E(R^r_{dsn}) = (\sigma(1-\eta)+\eta)\ell^{-\gamma}\Theta\Gamma\left(gA_G^{\frac{1}{\sigma(1-\eta)+\eta}} + (1-g)A_B^{\frac{1}{\sigma(1-\eta)+\eta}}\right)^{\sigma(1-\eta)+\eta}. \tag{14}$$

Plugging equations (13) and (14) into equation (12), we finally arrive at the expected profit from domestic sourcing under a rigid contract:

$$E(\pi^r_d) = \ell^{-\gamma}\Theta\Gamma\left(gA_G^{\frac{1}{\sigma(1-\eta)+\eta}} + (1-g)A_B^{\frac{1}{\sigma(1-\eta)+\eta}}\right)^{\sigma(1-\eta)+\eta} - F_d. \tag{15}$$

Completing backward induction, we can now state that risk-neutral headquarters engaged in domestic sourcing will choose a flexible contract if and only if $E(\pi^f_d) > E(\pi^r_d)$. Using equations (7) and (15), this condition can be written as

$$J := \frac{gA_G + (1-g)A_B}{\left(gA_G^{\frac{1}{\sigma(1-\eta)+\eta}} + (1-g)A_B^{\frac{1}{\sigma(1-\eta)+\eta}}\right)^{\sigma(1-\eta)+\eta}} > 1. \tag{16}$$

Note that $J = 1$ for $g = 0$, $g = 1$, or $A_G = A_B$. That is, firms are indifferent between the two contractual types in the absence of future uncertainty. We show in Appendix A.1 that $J > 1$ for all $g \in (0,1)$ and $A_G > A_B$. That is, in the presence of demand uncertainty and in the absence of ex-post adjustment costs, flexible contracts dominate rigid agreements. Further, we show that the attractiveness of flexible contracts increases in the degree of demand volatility. More specifically, let $v := (A_G - A_B)/A_G$ denote the sector-specific degree of volatility across states. Obviously, $v \in (0,1)$ if $A_G > A_B$, as assumed. Appendix A.1 also demonstrates that J is increasing in v, which means that the advantage of flexible contracting increases in the degree of volatility in a given sector. These results are summarized in

Lemma 1. *(i) $J > 1$ for all $A_G > A_B$ and $g \in (0,1)$, i.e., for $v > 0$. (ii) J increases in v.*

Proof. See Appendix A.1. □

Bearing in mind that labor adjustment costs in the domestic economy are normalized to zero, Lemma 1 implies that all firms engaged in domestic sourcing prefer flexible over rigid contracts.

Offshoring. Offshoring implies a lower price for the manufacturing component p_o, as given in equation (3), as well as a higher fixed cost of production $F_o > F_d$. Moreover, a flexible contract between H and a foreign supplier involves a higher labor adjustment cost, $F_{ao} > F_{ad} = 0$. Following the above approach, it is straightforward to show that offshoring under a *flexible* contract implies the state-contingent quantity of the manufacturing input:

$$m^f_{os} = \frac{(1-\eta)(\sigma-1)\omega\ell^{-\gamma}\Theta\Gamma A_s}{\tau w \ell}, \tag{17}$$

where $\omega := (\tau w)^{-\gamma}$ is defined for notational simplicity. The profit-maximizing levels of the headquarter input and revenue under a flexible contract are

$$h^f_{os} = \frac{\eta(\sigma-1)R^f_{os}}{\sigma} \quad , \quad R^f_{os} = \sigma\omega\ell^{-\gamma}\Theta\Gamma A_s.$$

The amount of manufacturing inputs sourced from a foreign supplier under a *rigid* contract reads

$$m^r_o = \frac{(1-\eta)(\sigma-1)\omega\ell^{-\gamma}\Theta\Gamma\left(gA_G^{\frac{1}{\sigma(1-\eta)+\eta}} + (1-g)A_B^{\frac{1}{\sigma(1-\eta)+\eta}}\right)^{\sigma(1-\eta)+\eta}}{\tau w\ell}, \tag{18}$$

and the corresponding headquarter input h^r_{os} and revenue R^r_{os} follow by complete analogy to equation (9), with subscript d being replaced by o. Note again that, even though the headquarter optimally adjusts after observing s in both types of contract, h^r_{os} differs from h^f_{os} because the stipulated amount of m is different under the two types of contract. Similarly, even though the headquarter faces the same price for the headquarter input for both $z = d, o$, she chooses different levels of h under domestic and foreign sourcing since the contracted quantity of m is different.

The expected maximum profits from offshoring under a flexible contract can be derived as:

$$E(\pi^f_o) = \omega\ell^{-\gamma}\Theta\Gamma(gA_G + (1-g)A_B) - F_o - F_{ao}, \tag{19}$$

while the expected maximum profits under a rigid contract are given by:

$$E(\pi^r_o) = \omega\ell^{-\gamma}\Theta\Gamma\left(gA_G^{\frac{1}{\sigma(1-\eta)+\eta}} + (1-g)A_B^{\frac{1}{\sigma(1-\eta)+\eta}}\right)^{\sigma(1-\eta)+\eta} - F_o. \tag{20}$$

Note that, in the case of foreign sourcing, the choice between flexible and rigid contracts involves the following trade-off: Since a flexible contract allows final good producers to optimally adjust to the realized state of demand, it is associated with higher operating profits, see Lemma 1. On the other hand, a flexible contract involves labor adjustment costs, F_{ao}. To allow for the coexistence of flexible and rigid contract in equilibrium and to generate a non-trivial trade-off between domestic sourcing and offshoring, we now make the following assumptions:

Assumption 1. *(i)* $\omega > J$; *(ii)* $\frac{F_o}{F_d} > \frac{\omega}{J}$; *(iii)* $\frac{F_{ao}}{F_o - F_d} > \frac{\omega(J-1)}{\omega - J}$.

This set of assumptions ensures that (i) offshoring is not always dominated by domestic sourcing, (ii) domestic sourcing is not always dominated by offshoring, and (iii) offshoring under rigid contracts is not always dominated by offshoring under flexible agreements.

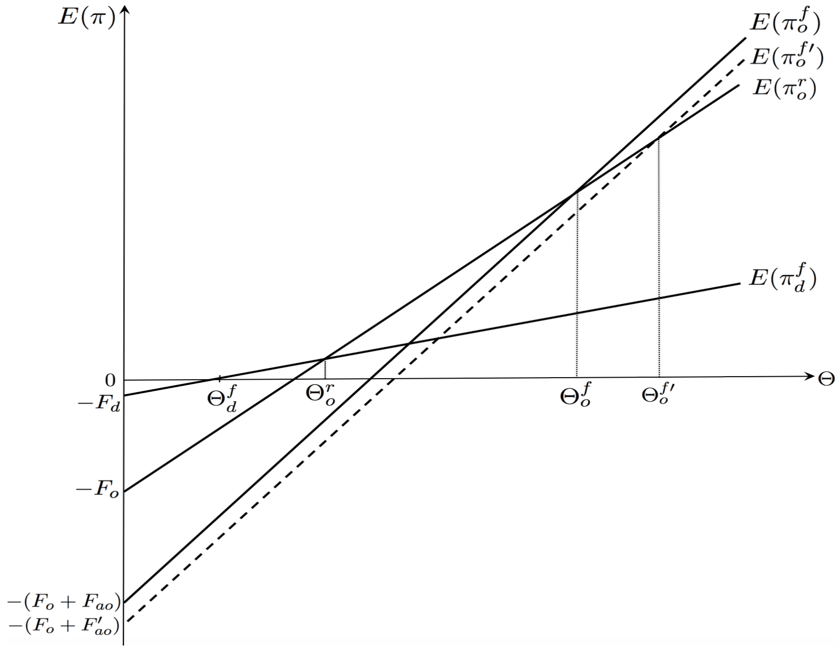

Figure 1: *Equilibrium sorting pattern under demand uncertainty.*

Based on these assumptions, Figure 1 depicts maximum profits under alternative sourcing strategies as a function of the (monotonically transformed) productivity measure Θ. The least productive firms, with $\Theta < \Theta_d^f$, do not start producing; firms with $\Theta \in [\Theta_d^f, \Theta_o^r)$ source m domestically; high-productivity firms, with $\Theta \geq \Theta_o^r$, are able to cover F_o and engage in offshoring. Among the offshoring firms, those with $\Theta \in [\Theta_o^r, \Theta_o^f)$ source inputs under a rigid contract, while firms with $\Theta \geq \Theta_o^f$ incur F_{ao} and source manufacturing components under flexible contracts. Using equations (7), (19) and (20), one can easily derive equilibrium productivity cutoffs:[12]

[12] Cutoff Θ_d^f is obtained from $E(\pi_d^f) = 0$; cutoff Θ_o^r from $E(\pi_d^f) = E(\pi_o^r)$; and cutoff Θ_o^f from $E(\pi_o^r) = E(\pi_o^f)$.

$$
\begin{aligned}
\Theta_d^f &= \frac{F_d}{\ell^{-\gamma}\Gamma(gA_G + (1-g)A_B)}, \\
\Theta_o^r &= \frac{J(F_o - F_d)}{\ell^{-\gamma}\Gamma(gA_G + (1-g)A_B)(\omega - J)}, \\
\Theta_o^f &= \frac{JF_{ao}}{\omega\ell^{-\gamma}\Gamma(gA_G + (1-g)A_B)(J-1)}.
\end{aligned} \tag{21}
$$

This completes the description of a firm's choice between domestic and foreign sourcing. Given that our empirical analysis of the determinants of offshoring is conducted using industry data, the following section derives testable industry-level predictions regarding the effect of a foreign country's labor market rigidity and its interaction with the sectoral volatility on the propensity of firms to source inputs from that country.

2.1.3 Testable predictions

Let $\Phi(\theta)$ denote the distribution function for firm productivity. Using this distribution function, and defining $\tilde{m}_z^f := gm_{zG}^f + (1-g)m_{zB}^f$, we can express the share of imported input purchases in a given industry as

$$
Y = \frac{\int_{\theta_o^r}^{\theta_o^f} p_o m_o^r \, \mathrm{d}\Phi(\theta) + \int_{\theta_o^f}^{\infty} p_o \tilde{m}_o^f \, \mathrm{d}\Phi(\theta)}{\int_{\theta_d^f}^{\theta_o^r} p_d \tilde{m}_d^f \, \mathrm{d}\Phi(\theta) + \int_{\theta_o^r}^{\theta_o^f} p_o m_o^r \, \mathrm{d}\Phi(\theta) + \int_{\theta_o^f}^{\infty} p_o \tilde{m}_o^f \, \mathrm{d}\Phi(\theta)}, \tag{22}
$$

whereby $\theta_d^f = (\Theta_d^f)^{\frac{1}{\sigma-1}}$, $\theta_o^r = (\Theta_o^r)^{\frac{1}{\sigma-1}}$, and $\theta_o^f = (\Theta_o^f)^{\frac{1}{\sigma-1}}$; the cutoffs Θ_d^f, Θ_o^r, and Θ_o^f are given by equation (21); p_z is given by equation (3); m_{ds}^f, m_{os}^f, and m_o^r are given by equations (5), (17), and (18), respectively. In words, the numerator of Y represents the value of inputs sourced from foreign suppliers (under rigid and flexible contracts), while the denominator denotes the total value of inputs sourced from domestic and foreign suppliers. In what follows, we refer to Y as the (U.S.) offshoring intensity.

We follow a large part of the heterogenous firm literature in assuming that productivities are distributed Pareto (see Antràs (2015) and Melitz and Redding (2014)):

$$
\Phi(\theta) = 1 - \left(\frac{\theta_{\min}}{\theta}\right)^{\kappa} \quad , \quad \theta \geq \theta_{\min} > 0 \quad , \quad \kappa > \sigma - 1, \tag{23}
$$

where $\theta_{\min}$ is the lower bound of the support and κ is a shape parameter of the productivity distribution. Utilizing (23) in (22) and simplifying the resulting expression we obtain

$$Y = \frac{\left(\frac{\Theta_o^f}{\Theta_o^r}\right)^{\frac{\kappa-(\sigma-1)}{\sigma-1}} + (J-1)}{\frac{J}{\omega}\left[\left(\frac{\Theta_o^f}{\Theta_d^f}\right)^{\frac{\kappa-(\sigma-1)}{\sigma-1}} - \left(\frac{\Theta_o^f}{\Theta_o^r}\right)^{\frac{\kappa-(\sigma-1)}{\sigma-1}}\right] + \left(\frac{\Theta_o^f}{\Theta_o^r}\right)^{\frac{\kappa-(\sigma-1)}{\sigma-1}} + (J-1)}, \tag{24}$$

whereby J is given by equation (16) and the productivity cutoffs are given by equation (21). Analyzing the first-order derivative of Y with respect to F_a, we obtain:

Proposition 1. *Under Assumption 1, an increase in the rigidity of a foreign country's labor market ceteris paribus decreases the U.S. offshoring intensity in a given industry, i.e.,* $\frac{\partial Y}{\partial F_{ao}} < 0$.

Proof. See Appendix A.2. □

The intuition behind this Proposition can be easily illustrated using Figure 1. An increase in foreign labor market rigidity ($F'_{ao} > F_{ao}$) reduces the expected profits from offshoring under a flexible contract ($E(\pi_o^f)$ shifts downwards) and induces offshoring firms in the productivity range $\Theta \in (\Theta_o^f, \Theta_o^{f\prime})$ to engage in rigid contracting instead. Given that firms in this range now expect lower operating profits (see Lemma 1), they source a smaller amount of manufacturing inputs from abroad. As a result, the offshoring intensity decreases.

We further show that a foreign country's labor market rigidity has a differential impact on U.S. offshoring intensity depending on this industry's volatility, as stated in

Proposition 2. *Under Assumption 1, the negative effect of foreign labor market rigidity on the U.S. offshoring intensity is more pronounced the higher an industry's volatility, i.e.,* $\frac{\partial^2 Y}{\partial F_{ao}\partial v} < 0$.

Proof. See Appendix A.2. □

To understand the logic behind this result consider, once again, Figure 1. Industries with a high degree of volatility are characterized by a more pronounced difference in the slopes of the lines $E(\pi_o^f)$ and $E(\pi_o^r)$. Intuitively, the advantage of flexible contracting weighs more heavily in industries where the good and the bad state of demand are further apart. Hence, if F_{ao} increases and some firms switch to a rigid contract, operating profits of those firms decrease more strongly and their reaction in terms of a reduced amount of imported inputs is more pronounced. At the same time, the range of firms affected by an increase in F_{ao} is smaller with a higher value of v, since the cutoff-shift from Θ_o^f to $\Theta_o^{f\prime}$ is smaller in magnitude when $E(\pi_o^f)$ and $E(\pi_o^r)$ are steeper. However, as shown in Proposition 2, the latter effect is dominated by the former.

To sum up, our model predicts a negative direct effect of a foreign country's labor market rigidity and a negative interaction between foreign labor market rigidity and an industry's volatility in their impact on the U.S. offshoring intensity. Before bringing these two predictions to the data, we briefly discuss the case of supply uncertainty to show that our two key propositions continue to hold under this alternative type of uncertainty.

2.2 Supply uncertainty

In this section, we provide an alternative version of our model with supply (rather than demand) uncertainty. More specifically, we now consider the risk associated with the production of manufacturing inputs m. As before, there are two states of nature, $s \in \{G, B\}$, which are verifiable by the courts. In the good (bad) state, a producer's unit labor requirement is ℓ_G (ℓ_B), $\ell_B > \ell_G$, whereby $g \in (0, 1)$ again is the probability of a good state. For simplicity, we assume the same g, ℓ_G, and ℓ_B for domestic and foreign suppliers in a given industry, but allow for differences in volatility across industries.

The timing is as in section 2.1.1. A *rigid* contractual arrangement means that in t_1 parties stipulate a fixed quantity m_z^r of manufacturing components to be delivered for a fixed price p_z^r in t_3. From the headquarter's perspective, such a contract effectively removes all uncertainty, hence the input h_z^r chosen in t_3 does not depend on s. In contrast, a *flexible contract* specifies a state-contingent amount and price of the manufacturing input chosen in t_1, m_{zs}^f and p_{zs}^f, and the headquarter input h_{zs}^f chosen in t_3 also depends on the state s. The per-unit price of m under the two-contractual types is given by:

$$p_z^r = \begin{cases} g\ell_G + (1-g)\ell_B & \text{if } z = d \\ \tau w[g\ell_G + (1-g)\ell_B] & \text{if } z = o \end{cases} \quad , \quad p_{zs}^f = \begin{cases} \ell_s & \text{if } z = d \\ \tau w \ell_s & \text{if } z = o \end{cases} \tag{25}$$

That is, a risk-neutral supplier from $z = d, o$ is willing to accept a rigid contract if the price offered by H is equal to her expected unit costs.[13] Under a flexible agreement, parties stipulate a state-contingent price which depends on the ex-post realization of a supplier's costs. As before, to secure a supplier's participation under a flexible contract, H has to compensate M's labor adjustment cost F_{az}, whereby $F_{ao} > F_{ad} = 0$. The game is solved by backward induction as in section 2.1.1.

[13] The underlying assumption here is that a perfect insurance market allows the supplier to hedge against the risk involved in accepting such a contract. Specifically, a domestic supplier is assumed to be able to buy m_z^r units of an asset paying out $\ell_B - p_z^r$ in the bad state, and sell the same amount of an asset which pays out $p_z^r - \ell_G$ in the good state. With probabilities g and $1-g$ for the good and the bad state, a perfect insurance market implies that the payments for the first type of transaction is equal to the revenues from the second. A similar argument is invoked for foreign suppliers.

We demonstrate in Appendix A.3 that this setup leads to the following set of maximum profits:

$$E(\pi_d^f) = [g\ell_G^{-\gamma} + (1-g)\ell_B^{-\gamma}]\Theta\Gamma A - F_d \tag{26}$$

$$\pi_d^r = [g\ell_G + (1-g)\ell_B]^{-\gamma}\Theta\Gamma A - F_d \tag{27}$$

$$E(\pi_o^f) = \omega[g\ell_G^{-\gamma} + (1-g)\ell_B^{-\gamma}]\Theta\Gamma A - F_o - F_{ao} \tag{28}$$

$$\pi_o^r = \omega[g\ell_G + (1-g)\ell_B]^{-\gamma}\Theta\Gamma A - F_o. \tag{29}$$

To avoid cluttered notation, we use the same symbols to denote profits in the case of supply uncertainty as in the case of demand uncertainty considered above. Notice that, in contrast to the case of demand uncertainty, a rigid contract now effectively eliminates all uncertainty as far as the headquarter firm is concerned. Once the rigid price is set to p_z^r, all risk is shifted to the supplier (who is assumed to be able to hedge against this risk).

Comparing the two types of contacting for $z = d$, with $F_{ad} = 0$, it is obvious that all firms sourcing domestically will choose a flexible contract. Indeed, redefining the term J as

$$J := \frac{g\ell_G^{-\gamma} + (1-g)\ell_B^{-\gamma}}{[g\ell_G + (1-g)\ell_B]^{-\gamma}}, \tag{30}$$

and the volatility measure as $v := (\ell_B - \ell_G)/\ell_B$, it is straightforward to verify that a statement completely analogous to Lemma 1 also obtains for supply uncertainty. More specifically, one can show that *(i)* $J > 1$ for all $\ell_G < \ell_B$ and $g \in (0;1)$, i.e., for $v > 0$, and *(ii)* J increases in v. Figure 1 may be used to illustrate the productivity-based sorting of firms into different sourcing locations and contractual arrangements (with $E(\pi_d^f)$ being replaced by π_d^f).[14] Under Assumption 1, we obtain the same sorting pattern as in the case of demand uncertainty: The least productive firms do not start producing, those with intermediate productivities source manufacturing inputs domestically, while only the most productive firms engage in offshoring. Among the offshoring firms, the least productive ones source inputs under a rigid contract, while the most productive ones engage in flexible contracting.

The relative propensity of offshoring under supply uncertainty can be defined as:

$$Y = \frac{\int_{\theta_o^r}^{\theta_o^f} p_o^r m_o^r \,\mathrm{d}\Phi(\theta) + \int_{\theta_o^f}^{\infty} \widetilde{pm}_o^f \,\mathrm{d}\Phi(\theta)}{\int_{\theta_d^f}^{\theta_o^r} \widetilde{pm}_d^f \,\mathrm{d}\Phi(\theta) + \int_{\theta_o^r}^{\theta_o^f} p_o^r m_o^r \,\mathrm{d}\Phi(\theta) + \int_{\theta_o^f}^{\infty} \widetilde{pm}_o^f \,\mathrm{d}\Phi(\theta)}, \tag{31}$$

whereby $\widetilde{pm}_z^f := g p_{zG}^f m_{zG}^f + (1-g) p_{zB}^f m_{zB}^f$; p_o^r and p_{zs}^f are given by equation (25); and

[14] Analytical expressions for the cutoffs Θ_d^f, Θ_o^r, and Θ_o^f are provided in Appendix A.3.

m_o^r, m_{zs}^f, θ_o^r, and θ_z^f are derived in Appendix A.3. Assuming that firm productivities are distributed Pareto, we arrive at an expression for Y which is identical to equation (24). This finally allows us to use the present definition of J from equation (30), in order to demonstrate that supply uncertainty leads to the same two Propositions as in the case of demand uncertainty above: The U.S. offshoring intensity in a given industry decreases in the rigidity of a foreign country's labor markets ($\frac{\partial Y}{\partial F_{ao}} < 0$), and this effect is particularly pronounced the higher an industry's volatility ($\frac{\partial^2 Y}{\partial F_{ao} \partial v} < 0$). We now turn to the empirical implementation of these predictions.

3 Empirical implementation

3.1 Econometric Specifications

Our empirical analysis of the determinants of offshoring proceeds in two steps. First, we investigate the effect of a variation in foreign labor market rigidity on U.S. offshoring intensity (Proposition 1). Second, we analyze the differential impact a foreign country's labor market rigidity on U.S. offshoring intensity depending on an industry's volatility (Proposition 2).

To examine the effect of foreign labor market rigidity on U.S. offshoring propensity, we test the following econometric model:

$$\ln Y_{lit} = \alpha \, rigidity_{lt} + \gamma \boldsymbol{X}_{lt} + \delta_l + \mu_i + \rho_t + \varepsilon_{lit}, \qquad (32)$$

whereby Y_{lit} measures the propensity of U.S. firms in industry i and year t to source manufacturing inputs from a foreign country l rather than from domestic producers. Our key explanatory variable in this specification is the rigidity of country l's labor market institutions in year t. The vector $\boldsymbol{X}_{lt}$ contains a set of time-varying country-level controls and ε_{lit} is an error term. δ_l represents country fixed effects (FE), which control for all time-invariant country-specific characteristics, such as geography (geographic distance, time difference, etc.), history (e.g., legal origin), as well as country-level factors that are relatively stable over time (e.g., language and culture). Industry fixed effects μ_i control for general characteristics of the goods produced in a given sector, such as technology, relationship-specificity, contractibility, etc. To account for aggregate time-specific shocks, we further include year fixed effects ρ_t. Based on Proposition 1, we expect a negative effect of a foreign country's labor market rigidity on the U.S. offshoring propensity, reflected in an estimate $\hat{\alpha} < 0$. Intuitively, since firms operating in rigid labor markets have to incur labor adjustment costs, the fraction of U.S. companies sourcing intermediate inputs from those markets is expected to be ceteris paribus smaller.

To be clear, the relationship between foreign labor market rigidity and U.S. offshoring prevalence estimated from equation (32) does not allow for causal interpretation. Even though the vector of controls, $\boldsymbol{X}_{lt}$ accounts for a range of observable time-varying country-level characteristics, there might be (unobservable) factors that vary across foreign destinations over time and confound this relationship.[15] To move closer towards identifying a causal effect of labor market institutions on the prevalence of offshoring, we explore the differential effect of labor market rigidity across U.S. industries that differ in their volatility. To this end, we estimate the following econometric model:

$$\ln Y_{lit} = \beta \, rigidity_{lt} \times volatility_i + \zeta \boldsymbol{X}_{lt} \times \boldsymbol{\chi}_i + \boldsymbol{\varphi} + \varepsilon_{lit}, \tag{33}$$

whereby $volatility_i$ captures the volatility of industry i, $\boldsymbol{\chi}_i$ is a vector of industry characteristics, and $\boldsymbol{\varphi}$ is a vector of fixed effects. Based on our Proposition 2, we expect a negative interaction effect between an industry's volatility and a country's labor market rigidity, $\hat{\beta} < 0$.

We consider two variants of the econometric model from equation (33), which differ regarding the composition of the vector $\boldsymbol{\varphi}$. In the first specification, this vector includes industry (μ_i) and country-year (δ_{lt}) fixed effects, whereby the latter effectively control for all time-varying country-specific factors that might have confounded the effect of labor market rigidity in specification (32).[16] The logic behind this model resembles a standard difference-in-difference approach, whereby the first differences are accounted for via country and industry fixed effects.[17] Yet, the fact that our key explanatory variable now varies by country-industry-year allows us to apply an even more stringent test. In the second specification, the vector $\boldsymbol{\varphi}$ includes country-industry (δ_{li}) and year (ρ_t) fixed effects. In so doing, we effectively control for all time-invariant country/industry characteristics (alongside with year-specific shocks). A remaining concern regarding the latter specification is that there might be other *time-varying* country/industry-specific factors that confound the effect of $rigidity_{lt} \times volatility_i$. To account for this possibility, we include a vector of country/year/industry controls, $\boldsymbol{X}_{lt} \times \boldsymbol{\chi}_i$, specified at length further below.

An important reservation regarding specifications (32) and (33) is an issue of selection.

15 Note that time-invariant country and industry characteristics are fully accounted for via country and industry fixed effects.

16 This specification is similar to Antràs (2015), apart from the fact that the author considers the interaction effect of an industry's volatility and a foreign county's labor market flexibility (an inverse of labor market rigidity) from a single year (2004) in a pooled OLS setting, see Table 5.7 in his book.

17 This approach has been previously exploited in the international trade literature to identify the effect of institutions on a country's comparative advantage, see, e.g., Chor (2010) and Nunn and Trefler (2014).

While our theoretical model focuses on the intensive margin of offshoring (i.e., the value of inputs sourced from a foreign destination in the total value of domestic and foreign sourcing), one might be concerned that the extensive offshoring margin (i.e., whether to offshore to a given foreign destination in the first place) is as well a function of a foreign country's labor market rigidity (or it's interaction with an industry's volatility). To account for the potential sample selection bias, we follow the approach suggested by Wooldridge (2010) and test for each year t the following Probit model: $\Pr(y = 1|\boldsymbol{x}) = Z(\boldsymbol{x}\psi)$, whereby the binary dependent variable, y is equal to one if the U.S. offshoring intensity Y_{lit} in a given year is positive and zero otherwise. $\boldsymbol{x}$ is a vector of controls containing $rigidity_{lt}$, $rigidity_{lt} \times volatility_i$, the vector of country/year covariates $\boldsymbol{X}_{lt}$ from equation (32), and a set of standard bilateral (gravity) controls $\boldsymbol{X}_{l,US}$ introduced further below. From these Probit regressions we obtain country/industry/year-specific inverse Mills ratios, $\hat{\lambda}_{lit}$ and add them to (some specifications) of equations (32) and (33).

3.2 Data Sources

The proxy for the U.S. offshoring intensity, Y_{lit} is drawn from Antràs (2015), who computes it as the ratio of U.S. imports from country l in industry i and year t to total U.S. absorption. The latter is defined as the sum of shipments by U.S. producers in industry i plus U.S. imports minus U.S. exports in that industry.[18] A higher U.S. offshoring share reflects a greater propensity of U.S. producers to source manufacturing inputs from foreign (rather than domestic) suppliers. This measure is available for 253 manufacturing sectors (according to IO2002 Input-Output industry classification) and 232 foreign countries for the period 2000-2011.

The measure of labor market $rigidity_{lt}$ in country l and year t is drawn from the World Bank's Doing Business data. Based on the methodology developed by Botero et al. (2004), this score is constructed as an average of the following three sub-indices: difficulty of hiring a new worker, restrictions on expanding or contracting the number of working hours, and difficulty of dismissing a redundant worker.[19] This score is available for 180 countries for the period 2004-2009.[20] Original scores vary on the scale between 0 (flexible labor market) and

[18] U.S. import and export data stem from the U.S. Census, and information on total shipments is drawn from the NBER-CES Manufacturing database (for 2000-09) and the Annual Survey of Manufacturing (for 2000-11), see Antràs (2015) for the details on the construction of this measure.

[19] Following the seminal contribution by Cuñat and Melitz (2012), (the inverse of) this index has been widely used in the international economics literature, see, e.g., Antràs (2015), Chor (2010), and Nunn and Trefler (2014). The yearly country scores, along with a more detailed description of their collection, are available online at `http://www.doingbusiness.org/reports/global-reports/doing-business-2004`.

[20] The World bank stopped reporting the index of labor market rigidity from 2010 onwards.

100 (rigid labor market). For expositional purposes, we rescale them to a unit interval and present them in Table B.1 in Appendix B. As can be seen from this table, U.S. has a third lowest average labor market rigidity, preceded only by Hong Kong and Singapore. Summary statistics for the main estimation sample are provided in Table B.3.

The proxy for $volatility_i$ of sector i is drawn from Antràs (2015), who computes it following the methodology by Cuñat and Melitz (2012). This measure is constructed as the employment-weighted standard deviation of the annual growth rate of firm sales in the 1980-2004 Compustat sample and is available for all manufacturing sectors (according to the IO2002 industry specification), for which we have information on the offshoring intensity (see above). Table B.2 in Appendix B presents the ten industries with the lowest and highest value of this index. As can be seen from this Table, the industry-level volatility varies between 0.0838 (Frozen food manufacturing) and 0.4155 (Computer storage device manufacturing). Before introducing further covariates, it is worth pausing to discuss the suitability of $volatility_i$ to reflect the notion of an industry's volatility assumed in the theoretical model. Although our model defines volatility as the deviation between a high and a low demand shifter (in case of demand uncertainty), or a high and low input costs (in case of supply uncertainty), firm revenue is a monotone function of the demand shifter and input costs (see, e.g., equations (5) and (A.1)). Hence, in the absence of industry-level data on the variation in demand shifters or input costs, the standard deviation of firm sales appears to be a suitable proxy for industry-level volatility in the context of our theoretical model.

Our baseline vector of time-varying country-level controls, $\boldsymbol{X}_{lt}$ includes the following six covariates: To account for a foreign country's market size, we control for the log of this country's real GDP in a given year, $\ln GDP_{lt}$, as reported by the Penn World Tables (version 8.1, see Feenstra et al. (2013)). We further include the log of GDP per capita (henceforth, $\ln(GDPpc)_{lt}$), taken from the Penn World Tables, as a proxy for a country's overall economic development. Clearly, labor market institutions constitute just one dimension of a foreign country's institutional environment. Legal and financial institutions have been identified as further important sources of a country's comparative advantage, see Antràs (2015), Chor (2010), Nunn (2007), and Nunn and Trefler (2014). Following this literature, we utilize the following two well-established proxies: To control for the quality of legal institutions, we use a country's 'Rule of Law' index (henceforth, $rule_{lt}$), reported in the World Bank's Worldwide Governance Indicators (see Kaufmann et al. (2010)); as a proxy for financial development, we use the log of private credit by deposit money banks and other financial institutions as a percentage of GDP (henceforth, $\ln(credit/GDP)_{lt}$), taken from the World Bank's Global Financial Development Database. To ensure that the effect of labor market institutions is not confounded by a country's physical and human capital abundance, we draw from the Penn World Tables the following two controls: log of physical capital stock per capita (henceforth, $\ln(K/L)_{lt}$) and human capital stock (henceforth, H_{lt}), calculated as the average years of schooling (see Barro and Lee (1996)). In the robustness checks, we consider further country controls introduced below.

The vector of industry-level characteristics, $\boldsymbol{\chi}_i$, used in the specification from equation (33), is drawn from Antràs (2015). Since the suitability of these proxies and their construction has been discussed at length in the original source, their introduction in the current paper is deliberately brief: $specificity_i$ captures the degree of relationship-specificity of goods produced in industry i, and is measured as the fraction of industry's products that are neither reference-priced nor traded on an organized exchange according to Rauch's (1999) 'liberal' classification; $dependence_i$ is a measure of industry dependence on external finance by Rajan and Zingales (1998), computed as the fraction of total capital expenditures not financed by internal cash flow; $Kintensity_i$ measures capital intensity and is calculated as the log of the real capital per worker in a given industry; $Sintensity_i$ approximates the skill intensity in a given industry, computed as the log of the number of non-production workers divided by total employment. In the robustness checks, we consider additional industry characteristics introduced further below.

To estimate the selection model specified in section 3.1, we draw from the CEPII database by Head et al. (2010) the following bilateral controls: the distance between the U.S. and a foreign country in log kilometers (as a proxy for transportation costs), the time difference in hours, and indicator variables for sharing a common border and the official language (Englisch). To account for the role of import tariffs in the decision of U.S. firms whether or not to offshore production to a given foreign destination, we further include an industry-specific measure of U.S. tariffs drawn from Antràs (2015).

3.3 Estimation Results

Table 1 summarizes our estimation results for different specifications of equation (32). Column 1 reports a negative and significant relationship between the U.S. offshoring intensity and a foreign country's labor market rigidity, controlling for country, industry, and year fixed effects. In columns (2)-(4), we successively add control variables for time-varying foreign countries' characteristics.[21] The relationship between the U.S. offshoring intensity and a foreign country's GDP per capita appears to be positive but only weakly significant. Yet, the negative coefficient of foreign labor market rigidity remains fairly robust in size and is

[21] Note that time-invariant country characteristics are fully controlled for via country fixed effects.

significant at the five percent level. In line with our Proposition 1, U.S. firms tend to offshore less to countries with rigid labor markets.

Table 1: U.S. offshoring intensity and foreign labor market rigidity (baseline results).

	Dependent variable: ln(U.S. offshoring intensity)$_{lit}$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$rigidity_{lt}$	-0.407**	-0.391**	-0.415**	-0.451**	-0.496**	-0.492**	-0.572**
	(0.183)	(0.186)	(0.186)	(0.203)	(0.233)	(0.239)	(0.223)
$\ln GDP_{lt}$		-0.001	-0.377	-0.727	-1.052	-1.047	-1.135
		(0.551)	(0.593)	(0.681)	(0.749)	(0.752)	(0.772)
$\ln(GDPpc)_{lt}$		0.462	0.865	1.323*	1.906**	1.926**	1.996**
		(0.521)	(0.580)	(0.672)	(0.747)	(0.750)	(0.785)
$rule_{lt}$			-0.030	-0.003	-0.036	-0.043	-0.291*
			(0.130)	(0.128)	(0.142)	(0.145)	(0.157)
$\ln(credit/GDP)_{lt}$			-0.105	-0.126	-0.196*	-0.198	-0.255**
			(0.095)	(0.101)	(0.112)	(0.120)	(0.124)
$\ln(K/L)_{lt}$				0.038	0.098	0.110	0.017
				(0.192)	(0.212)	(0.225)	(0.217)
H_{lt}				0.483	0.384	0.311	0.108
				(0.759)	(0.805)	(0.830)	(0.815)
Country, industry, year FE	yes	yes	yes	yes	yes	yes	yes
Sample restriction (Wright)	no	no	no	no	yes	yes	yes
Sample restriction (NT)	no	no	no	no	no	yes	yes
Sample selection correction	no	no	no	no	no	no	yes
Observations	105,938	102,796	97,406	92,697	66,214	62,493	62,225
R-squared	0.604	0.604	0.601	0.590	0.619	0.617	0.616

Note: The table reports estimates of equation (32) with ln(U.S. offshoring intensity)$_{lit}$ as a dependent variable. All specifications include country, industry, and year fixed effects. Standard errors are clustered at the country level and presented in parentheses. *, **, *** indicate significance at 1, 5, 10%-level, respectively.

We now discuss two limitations of the data and explore the robustness of our findings to the appropriate corrections, see columns (5) and (6). First, recall that our dependent variable is measured as the ratio of U.S. imports to total U.S. absorption in a given industry. Clearly, this measure potentially contains not only intermediate inputs purchases – which lie at the heart of our theoretical model – but also final good imports. To isolate the intermediate input component of U.S. imports, Antràs (2015) computes an alternative measure of U.S. offshoring shares based on the methodology developed by Wright (2014). More specifically, the author utilizes the Input-Output industrial categorization from the U.S. Bureau of Economic Analysis, to categorize highly disaggregated U.S. imports (classified according to the ten-digit Harmonized System, HS) into final goods and intermediate products. Removing from the sample all ten-digit HS codes associated with final good production and (re)aggregating the data to the IO2002 level, the author provides an adjusted proxy for U.S. intermediate input imports, used for the construction of ln(U.S. offshoring intensity)$_{lit}$ in column (5).[22] This sample restriction leads to the loss of observations in industries that

[22] See Data Appendix in Antràs (2015) for a detailed discussion of the methodology and its implementation.

consist entirely of final goods (e.g., 'Dog and cat food manufacturing'), which explains the drop in observations in column (5). Nevertheless, the association between the offshoring intensity and labor market rigidity continues to be negative and significant at the 5% level.

The second limitation of the data is that it does not allow us to distinguish between imports by U.S. headquarters and shipments from foreign headquarters to their U.S. affiliates. Since our theoretical model is set-up to characterize the former rather than the latter relationships, we follow Nunn and Trefler (2013) in applying the second (henceforth, NT) sample restriction. Using information on ownership links from the global database by the Bureau van Dijk, the authors trace all headquarter-subsidiary pairs in which either the headquarter of the subsidiary is from the U.S. and identify five countries for which the share of pairs with a U.S. parent is below 50 percent: Iceland, Italy, Finland, Liechtenstein, and Switzerland. Arguably, U.S. imports from those countries are driven by shipments from foreign headquarters to their U.S. affiliates and, therefore, are less likely to reflect U.S. offshoring intensity. As can be seen from column (6) of Table 1, removing these five countries from the sample has virtually no effect on the coefficient of labor market rigidity.

Although the log-linear specification in equation (32) is standard in the literature, it has a shortcoming of discarding all observations with zero U.S. import flows. In view of the fact that 57% of country/industry/year observations for which we have information on foreign labor market rigidity feature zero U.S. offshoring intensity, this caveat might appear to be not innocuous. To correct for potential selection bias, we enhance our econometric model with the inverse Mills ratios, calculated using the Probit selection model specified in section 3.1. As can be seen from column (7) in Table, the coefficient of labor market rigidity slightly increases after sample selection correction but remains significant at the 5% level.[23] A quantitative interpretation of our preferred specification in column (7) is that an increase in the labor market rigidity index by one standard deviation is associated with a lower U.S. offshoring intensity by approximately 1 percentage point.

We verify that the coefficient of foreign labor market rigidity remains fairly stable in size and significance after applying a range of robustness checks. In particular, one might be worried that the rule of law index included in our baseline regressions does not fully capture the variation in a country's legal institutions. To account for this concern, we successively enhance our preferred specification with the remaining five time-varying country-level scores

[23] We have further experimented with a log-linear specification along the lines of equation (32) and the dependent variable defined as $\ln(0.001 + Y_{lit})$, whereby Y_{lit} includes zero U.S. offshoring shares. In this specification, the size of the coefficient of labor market rigidity drops by an order of magnitude, but remains negative and significant at the five percent level. Given that our theoretical predictions are derived under the assumption of non-zero offshoring intensity (see Assumption 1 and Fig. 1), we do not report the results from this alternative specification and consider the estimates from column (8) as our baseline empirical test of Proposition 1.

of institutional quality reported in Worldwide Governance Indicators (see Kaufmann et al. (2010) for definitions and details on the construction of each score): control of corruption ($corruption_{lt}$), government effectiveness ($effectiveness_{lt}$), political stability and absence of violence ($stability_{lt}$), regulatory quality ($quality_{lt}$), and voice and accountability ($voice_{lt}$). As can be seen from Table 2, the coefficient of labor market rigidity is robust to these controls, included either separately or jointly into the preferred specification from column (7) of Table 1. Among all institutional covariates, only government effectiveness appears to be significantly correlated with the U.S. offshoring intensity and the sign of this estimate is positive. In unreported robustness checks, we have further experimented with the inclusion of alternative proxies for a foreign country's financial institutions from the World Bank's Global Financial Development Database. Throughout specifications, the coefficient of labor market rigidity is negative and significant at least at the five percent level.

Table 2: U.S. offshoring intensity and labor market rigidity (robustness).

	Dependent variable: ln(U.S. offshoring intensity)$_{lit}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$rigidity_{lt}$	-0.571**	-0.579***	-0.572**	-0.555**	-0.572**	-0.552**
	(0.230)	(0.218)	(0.223)	(0.228)	(0.222)	(0.235)
$corruption_{lt}$	-0.007					-0.066
	(0.109)					(0.119)
$effectiveness_{lt}$		0.176**				0.184**
		(0.086)				(0.087)
$stability_{lt}$			0.001			-0.018
			(0.057)			(0.060)
$quality_{lt}$				0.089		0.063
				(0.119)		(0.129)
$voice_{lt}$					0.004	0.012
					(0.091)	(0.103)
Observations	62,225	62,225	62,225	62,225	62,225	62,225
R-squared	0.616	0.616	0.616	0.616	0.616	0.616

Note: The table reports estimates of equation (32). All specifications include the full set of controls, fixed effects, and sample corrections as in column (7) of Table 1. Standard errors are clustered at the country-industry level and presented in parentheses. **, *** indicate significance at 5, 10%-level, respectively.

We now move towards a test of our Proposition 2. Controlling for country-year and industry fixed effects, we find a negative and highly significant interaction effect of a foreign country's labor market rigidity and industry-level volatility on the U.S. offshoring intensity, see column (1) in Table 3. In column (2), we add a set of country/industry/year-specific control variables. The rationale behind these interaction terms is as follows: $rule_{lt} \times specificity_i$ controls for the possibility that a variation in a foreign country's legal institutions may have a differential impact on the U.S. offshoring intensity depending on the degree of specificity of U.S. industries; $\ln(credit/GDP)_{lt} \times dependence_i$ controls for a differential impact of a foreign country's financial development on U.S. offshoring in industries that differ in their degree of external financial dependence; $\ln(K/L)_{lt} \times Kintensity_i$ and $H_{lt} \times Sintensity_i$ control for standard Heckscher-Ohlin effects, which suggest that a relatively capital abundant country will specialize (and export) capital-intensive goods, and a human capital abundant country will specialize on the provision of skill-intensive goods. After the inclusion of the above-mentioned country/industry/year-specific factors, the coefficient of $rigidity_{lt} \times volatility_i$ is reduced in size but remains highly significant, see column (2).

Table 3: U.S. offshoring intensity, labor market rigidity, and industry volatility (baseline).

	Dependent variable: ln(U.S. offshoring intensity)$_{lit}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$rigidity_{lt} \times volatility_i$	-9.032***	-5.415***	-5.443***	-2.034***	-2.153***	-1.965***
	(1.519)	(1.642)	(1.632)	(0.360)	(0.453)	(0.456)
$rule_{lt} \times specificity_i$		0.577***	0.647***	0.190***	0.101	0.090
		(0.052)	(0.087)	(0.064)	(0.082)	(0.083)
$\ln(credit/GDP)_{lt} \times dependence_i$		0.451***	0.170***	-0.118*	-0.181**	-0.181**
		(0.038)	(0.051)	(0.065)	(0.079)	(0.081)
$\ln(K/L)_{lt} \times Kintensity_i$		0.077***	-0.210***	0.017	0.018	0.012
		(0.021)	(0.067)	(0.015)	(0.020)	(0.020)
$H_{lt} \times Sintensity_i$		0.930***	0.110	-0.163	0.088	-0.010
		(0.088)	(0.126)	(0.211)	(0.280)	(0.285)
Country-year FE	yes	yes	yes	no	no	no
Industry FE	yes	yes	yes	no	no	no
Industry dummies×$\ln(GDPpc)_{lt}$	no	no	yes	yes	yes	yes
Country-industry FE	no	no	no	yes	yes	yes
Year FE	no	no	no	yes	yes	yes
Sample restriction (Wright)	no	no	no	no	yes	yes
Sample restriction (NT)	no	no	no	no	yes	yes
Sample selection correction	no	no	no	no	no	yes
Observations	105,933	92,696	92,696	89,839	60,086	59,063
R-squared	0.607	0.604	0.628	0.940	0.932	0.929

Note: The table reports estimates of equation (33) with ln(U.S. offshoring intensity)$_{lit}$ as a dependent variable. Standard errors are clustered at the country-industry level and presented in parentheses. *, **, *** indicate significance at 1, 5, 10%-level, respectively.

Recall from Table 1 that the U.S. offshoring intensity appears to be positively correlated with a foreign country's GDP per capita. While the direct effect of $\ln(GDPpc)_{lt}$ in the current specification is fully accounted for via country/year fixed effects, it is possible that a foreign country's economic development has a differential impact on U.S. offshoring intensity depending on an industry's characteristics. To control for a differential impact of a foreign country's $\ln(GDPpc)_{lt}$ across U.S. industries, we add a full set of interaction terms of a foreign country's GDP per capita with industry dummies.[24] As can be seen from column (3), the negative interaction effect of foreign labor market rigidity and industry volatility remains significant at the one percent level.

[24] This robustness check was originally suggested by Levchenko (2007) and has been subsequently used by Antràs (2015) in a context similar to the current paper.

In column (4), we perform an even more stringent test by controlling for country-industry and year fixed effects, which explains 0.94 percent of country/industry/year-variation in U.S. offshoring intensity. As a result, the coefficient of $rigidity_{lt} \times volatility_i$ drops in size by more than half but remains highly significant.[25] Moreover, it remains fairly robust to the Wright and NT sample restrictions (see column (5)), as well as to correction for potential sample selection bias (see column (6)).[26] Among all country/industry/year controls included, only $\ln(credit/GDP)_{lt} \times dependence_i$ remains significant in column (6). However, this interaction effect does not allow for a clear interpretation given that its coefficient changes sign from positive in columns (2)-(3) to negative in columns (4)-(6).

Table 4 exploits the robustness of the results to the inclusion of further country/industry/year controls into our preferred specification from column (6) of Table 3. More specifically, we draw from Antràs (2015) four alternative proxies for the contractibility of an industry's goods – constructed based on the methodologies suggested by Nunn (2007), Levchenko (2007), Costinot (2009), and Bernard et al. (2010) – and interact each of them with $rule_{lt}$ to allow for a differential impact of a foreign country's contracting institutions depending on the degree of contractibility of an industry's goods. Furthermore, we draw from Antràs (2015) an industry-level measure of asset $tangibility_i$ constructed based on the methodology by Braun (2002). The idea behind this measure is that tangible assets can be used as collaterals and, hence, firms in sectors with a high asset tangibility will be less financially constrained. Following Manova (2013), we interact this measure with $\ln(credit/GDP)_{lt}$, allowing a foreign country's financial development to differentially affect U.S. offshoring intensity depending on the extent to which firms in a given sector are financially constrained. As can be seen from Table 4 in Appendix B, the coefficient of $rigidity_{lt} \times volatility_i$ remains highly robust to the inclusion of the above-mentioned interaction terms. In unreported robustness checks, we have further experimented with including a broader set of additional and/or alternative country/industry/year controls (e.g., by using further institutional proxies from Table 2). Throughout specifications, we find a negative and significant interaction effect of a foreign country's labor market flexibility and an industry's volatility on U.S. offshoring intensity.

In summary, the empirical evidence lends strong support for our two theoretical predictions: U.S. firms tend to offshore less to countries with rigid labor markets and this effect is particularly pronounced in industries with a high degree of volatility. Our empirical findings are also consistent with the available evidence on the role of labor market institutions in international exchange. In a cross-section of countries and industries, Cuñat and Melitz

[25] The sample size is reduced because 2858 singleton observations are dropped.

[26] As before, we verify that our results are robust to an alternative definition of the dependent variable which includes zero offshoring shares, $\ln(0.001 + Y_{lit})$.

Table 4: U.S. offshoring intensity, labor market rigidity, and industry volatility (robustness).

	Dependent variable: ln(U.S. offshoring intensity)$_{lit}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$rigidity_{lt} \times volatility_i$	-1.990***	-2.003***	-1.975***	-1.984***	-1.966***	-1.999***
	(0.456)	(0.455)	(0.456)	(0.455)	(0.455)	(0.455)
$rule_{lt} \times contractibility_i$(Nunn)	-0.526**					0.412
	(0.215)					(0.412)
$rule_{lt} \times contractibility_i$(Levchenko)		-2.450***				-3.053***
		(0.599)				(0.961)
$rule_{lt} \times contractibility_i$(Costinot)			0.391			0.088
			(0.265)			(0.302)
$rule_{lt} \times contractibility_i$(Bernard)				-1.051**		-0.193
				(0.451)		(0.717)
$\ln(credit/GDP)_{lt} \times tangibility_i$					-0.538***	-0.518***
					(0.184)	(0.184)
Observations	59,063	59,063	59,063	59,063	59,063	59,063
R-squared	0.929	0.929	0.929	0.929	0.929	0.929

Note: The table reports estimates of equation (33). All specifications include the full set of controls, fixed effects, and sample corrections as in column (6) of Table 3. Standard errors are clustered at the country-industry level and presented in parentheses. **, *** indicate significance at 5, 10%-level, respectively.

(2012), Chor (2010) and Nunn and Trefler (2014) find that countries with more flexible labor market institutions – an inverse of the labor market rigidity index used in the current paper – concentrate their exports in sectors with greater volatility. In a pooled OLS setting, Antràs (2015) finds a positive interaction between a foreign country labor market flexibility (from the year 2004) and industry volatility in their impact on U.S. offshoring intensity. We complement the latter finding by exploiting time variation in a foreign country's labor market institutions, which allows us to more effectively control for unobserved heterogeneity across countries and industries using a battery of fixed effects.

4 Concluding Remarks

This paper develops a novel theoretical framework of offshoring under uncertainty. In our model, firms decide whether to source intermediate inputs from domestic or foreign suppliers, and whether to cooperate with a given producer under a rigid or flexible agreement against the backdrop of future demand or supply shocks. This model suggests that an increase in the rigidity of a foreign country's labor market ceteris paribus decreases the U.S. offshoring intensity in a given industry, whereby this negative effect is more pronounced the higher an industry's volatility. Combining data on the U.S. offshoring intensity with measures of labor market rigidity and industry volatility, we find empirical evidence supportive of the model's predictions. Our empirical findings are robust to controlling for a battery of fixed effects, alternative institutional measures, as well as industry-specific effects of a foreign country's economic development.

Our analysis leaves an important question open for future research. In order to focus on the choice between domestic and foreign sourcing, this paper disregarded a firm's decision whether to integrate a given supplier into its boundaries or cooperate with the latter at arm's-length. Introducing this internalization margin into the current framework would provide a more comprehensive understanding of the role of labor market rigidity and industry volatility in firms' global sourcing decisions under uncertainty.

A Mathematical Appendix

A.1 Proof of Lemma 1

Taking the first-order derivative of J from equation (16) with respect to A_G yields after simplification:

$$\frac{\partial J}{\partial A_G} = \frac{g(1-g)\left(A_G A_B^{\frac{1}{\sigma(1-\eta)+\eta}} - A_G^{\frac{1}{\sigma(1-\eta)+\eta}} A_B\right)}{A_G\left(g A_G^{\frac{1}{\sigma(1-\eta)+\eta}} + (1-g) A_B^{\frac{1}{\sigma(1-\eta)+\eta}}\right)^{\sigma(1-\eta)+\eta+1}},$$

whereby $\frac{\partial J}{\partial A_G} > 0$ if and only if $A_G A_B^{\frac{1}{\sigma(1-\eta)+\eta}} > A_G^{\frac{1}{\sigma(1-\eta)+\eta}} A_B$. The latter inequality is fulfilled if and only if $\left(\frac{A_B}{A_G}\right)^{-\frac{(1-\eta)(\sigma-1)}{\sigma(1-\eta)+\eta}} > 1$, which holds true for all $A_G > A_B$, $\eta \in (0,1)$, and $\sigma > 1$. Since $J = 1$ if $A_G = A_B$ and $\frac{\partial J}{\partial A_G} > 0$ for all $A_G > A_B$, we have $J > 1$ for all $A_G > A_B$.

Using the definition of v from the main text, we have $A_B = A_G(1-v)$. Substituting the latter in equation (16) and differentiating the resulting expression with respect to v yields after simplification:

$$\frac{\partial J}{\partial v} = \frac{g(1-g)A_G\left(((1-v)A_G)^{\frac{1}{\sigma(1-\eta)+\eta}} - (1-v)A_G^{\frac{1}{\sigma(1-\eta)+\eta}}\right)}{(1-v)\left(g A_G^{\frac{1}{\sigma(1-\eta)+\eta}} + (1-g) A_B^{\frac{1}{\sigma(1-\eta)+\eta}}\right)^{\sigma(1-\eta)+\eta+1}},$$

whereby $\frac{\partial J}{\partial v} > 0$ if and only if $((1-v)A_G)^{\frac{1}{\sigma(1-\eta)+\eta}} > (1-v)A_G^{\frac{1}{\sigma(1-\eta)+\eta}}$. The latter inequality is fulfilled if and only if $(1-v)^{-\frac{(1-\eta)(\sigma-1)}{\sigma(1-\eta)+\eta}} > 1$, which holds true for all $v, \eta \in (0,1)$, and $\sigma > 1$. We thus have $\frac{\partial J}{\partial v} > 0$.

A.2 Proof of Proposition 1 and 2

To simplify on notation, we employ the following three definitions: *(i)* $K := \frac{\kappa-(\sigma-1)}{\sigma-1}$, whereby $K > 0 \, \forall \, \kappa > \sigma - 1$, see definition of $\Phi(\theta)$ in eq. (23); *(ii)* $\Psi := \frac{\Theta_o^f}{\Theta_o^r}$, whereby $\Psi \geq 1 \, \forall \, \Theta_o^f \geq \Theta_o^r$, see Assumption 1*(iii)*; *(iii)* $\Omega := \frac{\Theta_o^f}{\Theta_d^f}$, whereby $\Omega \geq \Psi \, \forall \, \Theta_d^f \leq \Theta_o^f$, see Assumption 1*(ii)*.
The first-order derivative of Y with respect to F_{ao} reads after simplification:

$$\frac{\partial Y}{\partial F_{ao}} = -\frac{\omega K J (J-1)\left(\Omega^K - \Psi^K\right)}{F_a\left((\omega - J)\Psi^K + J\Omega^K + \omega(J-1)\right)^2} \leq 0,$$

whereby the sign of this derivative follows immediately from $J > 1$ (Lemma 1) and $\Omega \geq \Psi$.

Note that volatility v enters Y only via J. Bearing in mind that $J'(v) > 0$ (Lemma 1),

$\frac{\partial^2 Y}{\partial F_{ao}\partial J} < 0$ is a sufficient condition for $\frac{\partial^2 Y}{\partial F_{ao}\partial v} < 0$. The cross-partial derivative of Y with respect to F_{ao} and J reads after simplification:

$$\frac{\partial^2 Y}{\partial F_{ao}\partial J} = -\frac{\omega K \Upsilon}{F_{ao}(\omega - J)\left((\omega - J)\Psi^K + J\Omega^K + \omega(J-1)\right)^3},$$

whereby

$$\Upsilon := \Psi^K \left(\Omega^K(\omega^2(1+K)(2J-1) + J^2(2(1+K) - \omega(K+2)) - J\omega(1+2K)) + JK(\omega-1) + \omega - J\right) + \Omega^K(\omega - J)(1+K)(J\Omega^K - \omega(J-1)) + \Psi^{2K}(J-\omega)(J(1+K)(\omega-1) + \omega(J-1)).$$

In the following, we prove that $\Upsilon > 0$ for all permissible parameter values. Taking the first-order derivative of Υ with respect to Ω yields after simplification:

$$\frac{\partial \Upsilon}{\partial \Omega} = K\Omega^{K-1}T,$$

whereby

$$T := \Omega^K 2J(\omega-J)(1+K) - \omega(J-1)(\omega-J)(1+K) + \Psi^K\left(\omega^2(1+K)(2J-1) + J^2(2(1+k) - \omega(K+2)) - J\omega(1+2K)\right).$$

Note that the sign of $\frac{\partial \Upsilon}{\partial \Omega}$ is equal to the sign of T. To see that $T > 0$ for all permissible parameter values, note that T increases in Ω (recall that $\omega \geq J$ under Assumption 1*(i)*). Hence, if T is positive for the lowest possible $\Omega = \Psi$, it is positive for all $\Omega > \Psi$. Substituting $\Omega = \Psi$ in T yields after simplification:

$$T|_{\Omega=\Psi} = \omega\left(\Psi^K X - (\omega - J)(J-1)(1+K)\right),$$

whereby

$$X := J(1 + 2\omega(1+K)) - J^2(2+K) - \omega(1+K).$$

To establish the sign of $T|_{\Omega=\Psi}$, we first show that X is positive for all permissible parameter values. The first-order derivative of X with respect to ω reads after simplification $\frac{\partial X}{\partial \omega} = 1 + K(2J-1)$, which is strictly positive for all $J > 1$ (see Lemma 1). Hence, if X is larger than zero for the lowest possible $\omega = J$, it is strictly positive for all $\omega > J$. Substituting $\omega = J$ in X yields after simplification $X|_{\omega=J} = JK(J-1)$, which is clearly larger than zero for all $J > 1$. Since $X > 0$ for all permissible parameter values, $T|_{\Omega=\Psi}$ increases in Ψ. Hence, if $T|_{\Omega=\Psi} > 0$ holds for the lowest possible $\Psi = 1$, it holds a fortiori for all $\Psi > 1$. Evaluating

$T|_{\Omega=\Psi}$ at $\Psi = 1$ reads

$$T|_{\Omega=\Psi,\Psi=1} = J\omega(\omega - J + K(\omega - 1)) > 0,$$

whereby the sign of this expression follows immediately from $\omega \geq J > 1$ (see Assumption 1*(i)* and Lemma 1).

So far, we have shown that Υ increases in Ω, i.e., $\frac{\partial \Upsilon}{\partial \Omega} > 0$. Hence, if Υ is positive for the lowest possible $\Omega = \Psi$, we have $\Upsilon > 0$ for any $\Omega > \Psi$. Evaluating Υ at $\Omega = \Psi$ reads:

$$\Upsilon|_{\Omega=\Psi} = \Psi^K K\omega^2(J-1)\left((J-1) + \Psi^K\right) > 0,$$

whereby the sign of this expression follows immediately from the fact that $J > 1$ (Lemma 1). We thus have shown that $\frac{\partial^2 Y}{\partial F_{ao}\partial J} < 0$ and, therefore, $\frac{\partial^2 Y}{\partial F_{ao}\partial v} < 0$.

A.3 Derivations from section 2.2

Consider first domestic sourcing. Under a flexible contract, a headquarter chooses state-specific amounts of h and m that solve the problem $\max_{h,m} R - \ell_s m - h - F_d$. Using equations (2) and (1), profit-maximizing state-specific input quantities and revenues are

$$h^f_{ds} = \frac{\eta(\sigma-1)R^f_{ds}}{\sigma} \quad , \quad m^f_{ds} = \frac{(1-\eta)(\sigma-1)R^f_{ds}}{\ell_s \sigma} \quad , \quad R^f_{ds} = \sigma \ell_s^{-\gamma}\Theta\Gamma A, \tag{A.1}$$

whereby Θ, γ, and Γ are defined as in section 2.1.2. Note that the optimal amount of manufacturing components in the good (bad) state of the world is high (low, respectively). The maximum profit in state s is given by $\pi^f_{ds} = \ell_s^{-\gamma}\Theta\Gamma A - F_d$, and the expected maximum profit from domestic sourcing under a flexible contract is given by equation (26) in the main text.

Consider now a rigid contract. In t_3, a headquarter chooses the amount of headquarter services that maximizes $\max_h R - h - F_d$. Using equations (2) and (1), the optimal quantity of h and the associated revenue read

$$h^r_d = \frac{\eta(\sigma-1)R^r_d}{\sigma} \quad , \quad R^r_d = \left(\theta\left(\frac{\sigma-1}{\sigma}\right)^{\eta}\left(\frac{m^r_d}{1-\eta}\right)^{1-\eta}\right)^{\frac{\sigma-1}{\sigma(1-\eta)+\eta}} A^{\frac{1}{\sigma(1-\eta)+\eta}}. \tag{A.2}$$

Notice from the comparison of equations (9) and (A.2) that, in contrast to the case of demand uncertainty, the optimal amount of headquarter services is no longer state-specific. The net revenue from a rigid contract reads $R^r_{dn} = \frac{\sigma(1-\eta)+\eta}{\sigma}R^r_d$, whereby R^r_d is given by the second expression in equation (A.2). In t_1, the headquarter stipulates a fixed amount of m that solves $\max_m R^r_{dn} - [g\ell_G + (1-g)\ell_B]m - F_d$. Using equation (A.2), the optimal amount of manufacturing inputs stipulated under a rigid contract can be calculated as

$$m^r_d = \frac{(1-\eta)(\sigma-1)[g\ell_G + (1-g)\ell_B]^{-\gamma}\Theta\Gamma A}{g\ell_G + (1-g)\ell_B}, \tag{A.3}$$

and the associated profit under a rigid contract is given by equation (27) in the main text.

Equilibrium input quantities and profits under offshoring can be derived by analogy. In particular, the amount of manufacturing inputs offshored under a flexible contract in state s is given by

$$m^f_{os} = \frac{(1-\eta)(\sigma-1)\omega\ell_s^{-\gamma}\Theta\Gamma A}{\tau w\ell_s}, \tag{A.4}$$

whereby ω is defined as in section 2.1.2, and the amount of m offshored under a rigid agreement reads:

$$m^r_{os} = \frac{(1-\eta)(\sigma-1)\omega[g\ell_G + (1-g)\ell_B]^{-\gamma}\Theta\Gamma A}{g\ell_G + (1-g)\ell_B}. \tag{A.5}$$

The expected maximum profit from offshoring under a flexible contract is given by equation (28), while the maximum profit from offshoring under a rigid contract is by (29).

Under Assumption 1, the equilibrium cutoffs under supply uncertainty read:

$$\begin{aligned} \Theta^f_d &= \frac{F_d}{[g\ell_G + (1-g)\ell_B]^{-\gamma}\Gamma A}, \\ \Theta^r_o &= \frac{J(F_o - F_d)}{[g\ell_G + (1-g)\ell_B]^{-\gamma}\Gamma A(\omega - J)}, \\ \Theta^f_o &= \frac{JF_{ao}}{\omega[g\ell_G + (1-g)\ell_B]^{-\gamma}\Gamma A(J-1)}. \end{aligned} \tag{A.6}$$

B Tables

Table B.1: List of countries by labor market rigidity, averaged over 2004-2009.

Rank	Country	Rigidity	Rank	Country	Rigidity	Rank	Country	Rigidity
1	HKG	0.000	61	GMB	0.260	121	LTU	0.445
2	SGP	0.000	62	MUS	0.262	122	CIV	0.447
3	USA	0.010	63	ISR	0.263	123	RWA	0.452
4	MHL	0.022	64	LSO	0.272	124	TJK	0.455
5	PLW	0.032	65	AZE	0.275	125	IRQ	0.456
6	BRN	0.047	66	CHN	0.277	126	TUR	0.457
7	MDV	0.050	67	OMN	0.277	127	ITA	0.458
8	UGA	0.055	68	ISL	0.284	128	DJI	0.460
9	CAN	0.057	69	URY	0.288	129	FIN	0.462
10	JAM	0.060	70	BLR	0.288	130	BDI	0.462
11	LCA	0.067	71	BGD	0.293	131	BEN	0.467
12	TTO	0.070	72	LBR	0.297	132	NPL	0.467
13	NZL	0.070	73	JOR	0.298	133	IDN	0.470
14	AUS	0.072	74	ZWE	0.302	134	KHM	0.470
15	TON	0.082	75	LKA	0.302	135	CPV	0.470
16	FSM	0.086	76	SVK	0.303	136	DEU	0.473
17	MYS	0.088	77	MNE	0.308	137	DZA	0.480
18	WSM	0.096	78	AFG	0.310	138	MLI	0.483
19	ATG	0.100	79	SLV	0.315	139	TUN	0.487
20	BLZ	0.112	80	MNG	0.317	140	MDA	0.493
21	SAU	0.120	81	HUN	0.322	141	LVA	0.493
22	PNG	0.120	82	COL	0.327	142	MEX	0.497
23	GBR	0.132	83	BGR	0.327	143	ECU	0.500
24	KWT	0.132	84	YEM	0.328	144	UKR	0.502
25	KNA	0.135	85	GTM	0.330	145	PER	0.510
26	DNK	0.135	86	SYR	0.330	146	PRT	0.510
27	VCT	0.142	87	ARM	0.332	147	BRA	0.513
28	SWZ	0.142	88	POL	0.338	148	TWN	0.517
29	BHS	0.150	89	NIC	0.338	149	HRV	0.523
30	SLB	0.158	90	GHA	0.338	150	CMR	0.528
31	CHE	0.163	91	CRI	0.342	151	EST	0.533
32	BHR	0.165	92	DOM	0.345	152	MOZ	0.537
33	DMA	0.165	93	KGZ	0.347	153	MRT	0.552
34	FJI	0.166	94	SCG	0.348	154	GAB	0.555
35	KIR	0.170	95	ALB	0.352	155	TCD	0.562
36	GRD	0.195	96	SYC	0.355	156	BFA	0.568
37	BEL	0.195	97	ETH	0.357	157	GRC	0.577
38	QAT	0.200	98	VNM	0.358	158	ROU	0.578
39	GEO	0.200	99	AUT	0.358	159	MDG	0.578
40	JPN	0.203	100	PHL	0.373	160	SVN	0.583
41	BWA	0.205	101	UZB	0.377	161	PRY	0.585
42	HTI	0.207	102	RUS	0.378	162	FRA	0.587
43	NGA	0.207	103	LAO	0.380	163	ESP	0.598
44	THA	0.208	104	TLS	0.384	164	LUX	0.600
45	ARE	0.210	105	KOR	0.388	165	SLE	0.603
46	GUY	0.212	106	ARG	0.395	166	SEN	0.617
47	ERI	0.214	107	EGY	0.400	167	STP	0.624
48	KAZ	0.222	108	IND	0.402	168	TGO	0.630
49	CHL	0.222	109	IRN	0.412	169	MAR	0.632
50	MWI	0.223	110	SDN	0.412	170	TZA	0.635
51	KEN	0.225	111	SWE	0.417	171	PAN	0.638
52	SUR	0.225	112	HND	0.423	172	BOL	0.648
53	IRL	0.232	113	GIN	0.428	173	GNB	0.658
54	NAM	0.233	114	MKD	0.428	174	GNQ	0.660
55	CYP	0.240	115	BIH	0.430	175	CAF	0.662
56	ZMB	0.248	116	NOR	0.433	176	VEN	0.662
57	VUT	0.250	117	NLD	0.433	177	AGO	0.673
58	CZE	0.250	118	ZAF	0.440	178	COG	0.727
59	LBN	0.252	119	COM	0.445	179	COD	0.760
60	BTN	0.258	120	PAK	0.445	180	NER	0.775

Note: The table lists ISO3 country codes sorted in ascending order by the index of labor market rigidity.

Table B.2: Ten industries with the lowest and highest degree of volatility.

$volatility_i$	10 industries with the lowest degree of volatility
0.0838	Frozen food manufacturing
0.0956	Photographic and photocopying equipment manufacturing
0.1034	Vending, commercial, industrial, and office machinery manufacturing
0.1046	Stationery product manufacturing
0.1046	All other converted paper product manufacturing
0.1046	Coated and laminated paper, packaging paper and plastics film manufacturing
0.1078	Breweries
0.1135	All other paper bag and coated and treated paper manufacturing
0.1146	Other concrete product manufacturing
0.1146	Ready-mix concrete manufacturing
...	10 industries with the highest degree of volatility
0.2873	Fluid milk and butter manufacturing
0.3004	Storage battery manufacturing
0.3004	Primary battery manufacturing
0.3060	Electronic capacitor, resistor, coil, transformer, and other inductor manufacturing
0.3060	Electron tube manufacturing
0.3119	Irradiation apparatus manufacturing
0.3127	Bare printed circuit board manufacturing
0.3360	Switchgear and switchboard apparatus manufacturing
0.3992	Biological product (except diagnostic) manufacturing
0.4155	Computer storage device manufacturing

Table B.3: Summary statistics for the main estimation sample.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
ln(U.S. offshoring intensity)$_{lit}$	62,225	-9.387	3.401	-21.268	-0.146
$rigidity_{lt}$	62,225	0.363	0.182	0.000	0.900
$\ln GDP_{lt}$	62,225	12.447	1.595	7.501	16.154
$\ln(GDPpc)_{lt}$	62,225	9.389	0.998	5.732	11.733
$rule_{lt}$	62,225	0.371	0.987	-1.843	2.000
$\ln(credit/GDP)_{lt}$	62,225	3.972	0.856	0.063	5.568
$\ln(K/L)_{lt}$	62,225	10.441	1.123	6.696	12.546
H_{lt}	62,225	2.719	0.469	1.174	3.536
$corruption_{lt}$	62,225	0.391	1.052	-1.571	2.549
$effectiveness_{lt}$	62,225	0.536	0.935	-1.769	2.430
$stability_{lt}$	62,225	0.023	0.908	-2.627	1.514
$quality_{lt}$	62,225	0.536	0.870	-2.210	1.991
$voice_{lt}$	62,225	0.376	0.893	-1.775	1.826
$rigidity_{lt} \times volatility_i$	59,063	0.067	0.039	0.000	0.328
$rule_{lt} \times specificity_i$	59,063	0.305	0.853	-1.787	2.000
$\ln(credit/GDP)_{lt} \times dependence_i$	59,063	1.135	1.957	-6.147	16.464
$\ln(K/L)_{lt} \times Kintensity_i$	59,063	49.403	9.551	20.996	89.989
$H_{lt} \times Sintensity_i$	59,063	-3.320	1.221	-8.172	-0.428
$rule_{lt} \times contractibility$(Nunn)$_i$	59,063	0.180	0.501	-1.569	1.938
$rule_{lt} \times contractibility$(Levchenko)$_i$	59,063	0.048	0.152	-0.968	1.050
$rule_{lt} \times contractibility$(Costinot)$_i$	59,063	-0.216	0.574	-2.000	1.843
$rule_{lt} \times contractibility$(Bernard)$_i$	59,063	0.148	0.382	-1.157	1.418
$\ln(credit/GDP)_{lt} \times tangibility_i$	59,063	1.133	0.459	0.012	3.529

Note: The table reports summary statistics for the main estimation sample used in Tables 1, 3, 2, and 4.

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